Knitting Science (1)

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Learning Objectives

- Aspect of Knitting Science
- Relaxation and shrinkage
- Fabric geometry and K-value
- Cover Factor
- HARTA Research

Ref: Machine Knitting and Fabrics by K.F. Au, Chapter 24, Plain Knit Fabric Geometry
Aspect of Knitting Science

- Using a scientific approach to study knitted fabric especially with knitted garment size variation.

- Three Basic Laws were established on knitted fabric behavior (by Hatra Research)
  - Loop length is the fundamental unit of weft knitting structure;
  - Loop shape determines the dimensions of the fabric and this shape depends upon yarn used, treatment and fabric received;
  - The relationship between loop shape and loop length may be expressed in the form of simple equations
Relaxation and shrinkage

- Knitted fabric tends to change in width and length when taken from machine, even without yarn shrinkage, indicates a change in loop shape rather than loop length.

- During knitting, the loop structure is subjected to tension from take down mechanism. This “stressed” fabric will relax once more favorable conditions provided.

- e.g. during washing and wearing with results in change of dimension and customer satisfaction.
Knitted fabric geometry

Two fundamental factors for fabric geometry theory:

- the stitch length, i.e. the length in the knitted loop, is the dominant factor in all structure.
- There are several dimensionally stable states possible for a knitted structure.
Relaxation States

- The three "relaxed states" for knitted fabrics are:
  - Dry relaxed states: the fabric has been taken off the knitting machine and in course of time, attains a dimensionally stable condition.
  - Wet relaxed states: if the fabric is soaked in water and allowed to dry flat, the wet-relaxed state is attached, again a dimensionally stable condition;
  - Finished relaxed states: to reach this stable condition, the fabric is subjected to agitation in water or steam, and a denser fabric results.
Doyle’s experiment

- The stitch length and fabric dimension when under dry, relaxed state is constant and is independent of yarn type, yarn count, machine type and machine gauge.
K-factor (1)

- Doyle showed that (from expt. Data) for a range of dry, relaxed plain weft fabric, the stitch density $S$ is $S = K_s / l^2$
  - where $S$ is stitch density, and,
  - $l$ is loop length, and,
  - $K_s$ is constant and independent of yarn and machine variable.
Munden showed that (1959) there are linear dimension as well as stitch density for a wide range of relaxed plain fabrics. He suggested, the dimensions of plain fabric:

- \( \text{cpi} = \frac{K_c}{L} \);
- \( \text{wpi} = \frac{K_w}{L} \);
- \( S = \frac{K_s}{L^2} \); and
- \( \frac{\text{cpi}}{\text{wpi}} = \frac{K_c}{K_w} = R \) where \( R \) is loop shape factor.
K-factor (3)

- Knapton further works on “K” value for different “relaxed state” fabric as follows:

<table>
<thead>
<tr>
<th></th>
<th>Dry Relaxed</th>
<th>Wet Relaxed</th>
<th>Fully Relaxed</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K_s$</td>
<td>19.0</td>
<td>21.6</td>
<td>23.1</td>
</tr>
<tr>
<td>$K_c$</td>
<td>5.0</td>
<td>5.3</td>
<td>5.5</td>
</tr>
<tr>
<td>$K_w$</td>
<td>3.8</td>
<td>4.1</td>
<td>4.2</td>
</tr>
<tr>
<td>$R$</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
</tr>
</tbody>
</table>
Cover Factor

- Cover factor is ratio of the area covered by the yarn in one loop to the area occupied by that loop.

- Area of yarn in one loop = \( l \times d \)

- Area taken by one loop = \( \frac{1}{cpi} \times \frac{1}{wpi} = \frac{1}{S} \)
  - Since \( S = \frac{K_s}{l^2} \);

- Cover factor = \( l \times d \times S = l \times d \times \frac{K_s}{l^2} \)

- Assume \( d = \sqrt{\text{tex}} \)

- Cover factor = \( \frac{\sqrt{\text{tex}}}{l} \)
HATRA Research

- Hoisery and Allied Trade Research Association (HATRA) shows that the quality, weight and dimensions of fabric as it comes off the knitting machines are affected by FOUR factors. They are:
  - dimensional and gauge of machine;
  - yarn count and quality;
  - take-down tension; and
  - length of yarn knitted into the stitch
First, what is fabric quality? The general trade interpretation is that two fabrics are of same quality when

- their weights per unit area are the same;
- their course per inch and wales spacing are similar;
- their handles are identical; and
- their elastic properties are the same.
Fabric Quality (2)

For two fabrics to conform to these four requirements, and be of identical quality; when
  – the fabrics are knitted from yarns of similar count and quality;
  – the constructional details of the fabrics are identical

So the only factors affecting two fabric’s identical quality are:
  – take down tensions on the machine;
  – length of yarn knitted into a stitch
Effect of take down tension

- It have been showed that the higher the fabric take down tension, the narrower the fabric width and the lower value of course per inch.
- However, this effect is only temporary on fabric dimensions and quality; these difference will disappear when fabric is thoroughly relaxed such as after wetting out or washing.
Conclusion

- HATRA Research proves that
- The last thing affects the fabric quality is stitch length.